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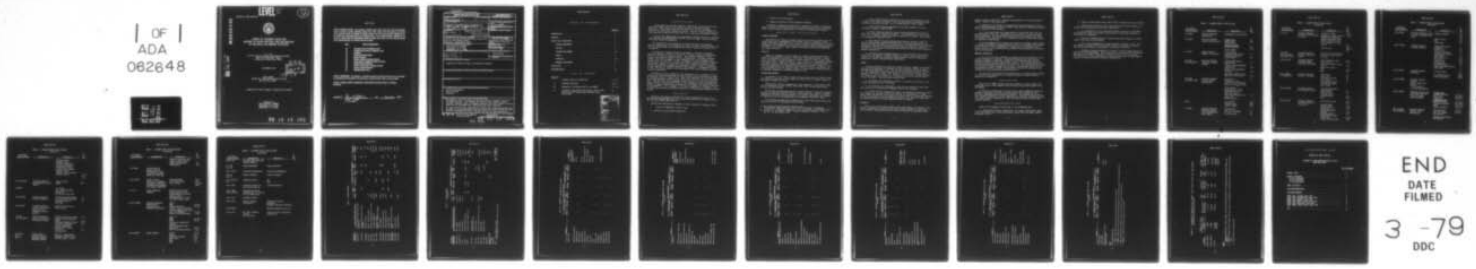

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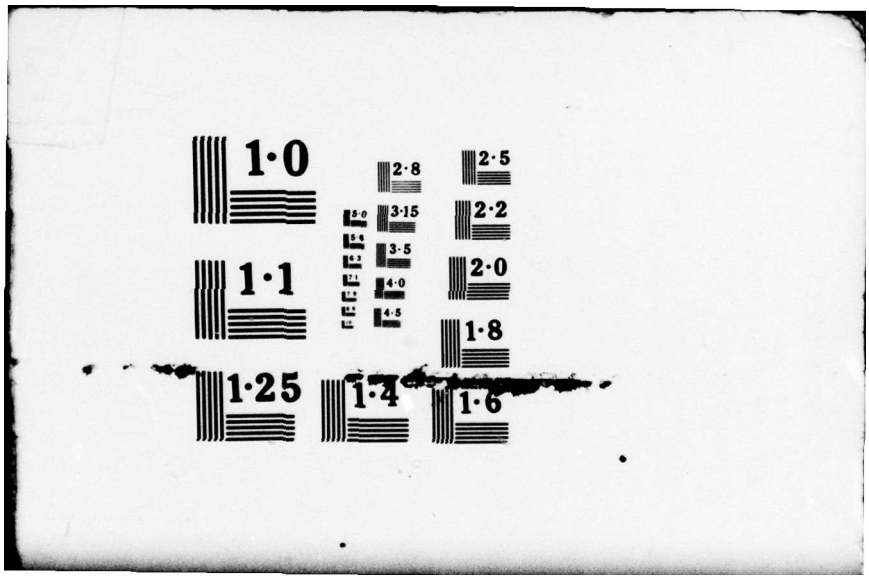
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# SURVEY OF CLEANERS USAGE AND METHODS OF WASTE DISPOSAL AND RECLAMATION AT THE NAVAL AIR REWORK FACILITIES

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14 NOVEMBER 1978

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AIRTASK NO. A340-0000/001B/6F57-572-401
Work Unit No. VQ301

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Prepared for
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Approximately 624,725 pounds and 186,000 gallons of cleaners are used by the NARFs surveyed. The combined formulas of these cleaners contain thirteen different types of inorganic chemicals and sixty organic chemicals which are not reclaimed after application and waste treatment.

To reduce pollution and simultaneously effect cost savings, recommendations are made for the replacement by the most efficient cleaner having the least pollutive components for other cleaners used for the same application.

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# INTRODUCTION

A large number of cleaning compounds representing a broad range of inorganic and organic chemicals are used by the Navy in diverse cleaning operations. Should these chemicals find their way into the environment, unfavorable and deleterious effects may result. Certain of these materials will cause immediate problems and others will cause long term environmental damage.

It is for this reason that the investigation reported herein was initiated under AIRTASK A340-0000/001B/6F57-572-401, Work Unit VQ301, Pollution Control in Aircraft Materials/Components.

The objective of this program is to abate pollution by reclamation, material substitution, or by reducing the amount of waste cleaner effluent that must be treated before final disposal into such a facility as stream, river or landfill.

In nearly all cleaning operations performed at the Naval Air Rework Facilities (NARFS) surveyed in this report, the part cleaned is flushed with water to rinse off the residual wastes. This effluent composed of dirt, cleaner, and enormous volumes of water is channelled to the waste treatment facility and after treatment is then discharged into the environment via a stream, river, or the like. However, treatment is largely ineffectual because the enormous volumes of water cause such a great degree of dilution of the cleaner that chemical treatment for breakdown, conversion and/or reclamation of the components is extremely difficult and expensive. Although the dilution is high, the adverse effect on the environment still exists through concentration by accumulation.

The impact of waste cleaners on the environment can be lessened by eliminating those cleaners performing the same function and by minimizing the number of different types of cleaners used. This latter approach can be accomplished by determining which cleaners can be substituted for by non (or less) pollutive ones. The selection of a recommended cleaner of equal or superior performance would be based on the probable impact of the components on the environment and methods of waste treatment from a standpoint of economics and chemical reactivity of the components. If a component of a cleaner formulation is hazardous, substitution by an analog with similar chemical, but non-hazardous properties should be made.

# APPROACH

Surveys of the types of cleaners and cleaner formulations used by the military services and specifically the types and quantities of cleaners used by the individual NARFS were conducted.

Studies were made of each component in these cleaners to determine their:

1. Pollutive or hazardous nature, if any.

2. Function in the cleaner formulation

3. Effect on the environment.

4. Chemical activity for waste disposal treatment.

In addition, studies were made aimed at reducing the number of different types of cleaners performing the same or equivalent function, and to determine which cleaners could be substituted for by non or less pollutive cleaners.

## RESULTS AND DISCUSSIONS

### CLEANER COMPONENTS

The study of all types of cleaners used by the military indicate that the formulations utilize approximately 14 different types of inorganic and 60 organic chemicals, among which, are 6 types of surface active agents or synthetic detergents. This represents a spectrum of 41 Federal, Military Specifications and proprietary cleaners. These cleaners with their function and components are listed in Table 1.

### TOXICITY

Among the components of the cleaners are several chemicals which must be rated as non-acceptable materials. These are: Potassium chromate, a recognized carcinogen** and sodium cyanide, a deadly poison.* Other cleaner components with toxicity hazard ratings* of 3 are: Oxalic acid, aluminum trichloride and diethyl amine. Additional cleaner components such as sodium hydroxide, potassium hydroxide, and triethanolamine have toxicity hazard ratings of 3 and 2 in the concentrated form; however, their levels of toxicity are greatly reduced immediately prior to disposal because of their extreme solubility even if no chemical breakdown or conversion process is used.

### CLEANER REPLACEMENT

An analysis of the cleaner systems and their applications in Table 1 indicate possible reduction in their number by substitution of cleaners capable of the same or similar functions.

Specifically, based on examination of the components, cleaner MIL-C-43616 can be substituted for MIL-C-11090, MIL-C-25769, and for some applications, P-C-444 and MIL-C-22542A.

MIL-C-43616 "Cleaning Compound for Aircraft Surfaces" is used for cleaning painted and unpainted aircraft surfaces. This cleaner is a superior cleaning compound for aircraft surfaces because of its greater efficiency, cost, method of application and is environmentally more acceptable than PC-444 Type 2.

The following describes the disadvantages of each substituted cleaner and justification for its replacement by MIL-C-43616:

---

* The reference source used for toxicity hazard ratings is "Dangerous Properties of Industrial Materials: by N. Irving Sax, Fourth Edition 1975

** Listed as a carcinogen by OSHA - Chemical Regulation Reporter - Vol. 2, No. 16 - 21 July 1978 p. 629

1. MIL-C-11090 "Cleaning Compound, Solvent, Self Emulsifying" is used to remove oils, greases, asphalts, tars and preservative type materials from metallic and painted surfaces. It is a harsh and more costly cleaner.

2. MIL-C-25769 "Cleaning Compound for Aircraft Surfaces" is not as efficient a cleaner as MIL-C-43616.

3. PC-444 "Cleaning Compound, Solvent Grease Emulsifying" is used for heavy duty cleaning on unpainted surfaces. Its disadvantage is that it consists of a 2 component system that must be mixed prior to usage. MIL-C-43616 was formulated to replace P-C-444.

4. MIL-C-22542A "Cleaning Compound High Pressure Cleaner, Liquid" is used in high pressure steam cleaning machines for cleaning painted and unpainted aircraft surfaces and to neutralize acid in specialized paint stripping operations. However, steam cleaning of aircraft with high heat, pressure, and alkali is too severe a process and MIL-C-43616 can fulfill this function at ambient temperatures.

5. For Engine Cooling System Cleaners, it was determined that cleaner MIL-C-10597 can replace O-C-00432 because the former is more effective as a cleaner, and in addition, possesses conditioning and corrosion inhibiting properties. Table I contains these formulations.

## SURVEY

A survey was made of the Naval Air Rework Facilities (NARFS) to determine what types and quantities of cleaners are used per annum, methods of waste disposal and reclamation if any. The types and quantities are given in Table II. The components in these cleaners and the toxic hazard rating of each component are listed in Table III. However, it is felt that in some instances the survey is not all inclusive but it represents the major cleaners being used at the NARFS. The survey does indicate that:

1. No efforts are being made to recover or reclaim the effluent of the cleaning compounds at any of the NARFS.

2. The effluents are discharged to some type of industrial waste treatment facility for processing or breakdown before final disposal.

3. Aircraft surface cleaner MIL-C-43616, an extremely efficient and effective cleaner can very well fulfill and surpass the requirements of cleaner MIL-C-11090, MIL-C-25769, MIL-C-22542, and also P-C-444 for certain applications. By these replacements, the environmental pollution load would be lessen since the different types of cleaner components would be reduced.

## ECONOMICS

Based on the total usages of MIL-C-25769, MIL-C-22542, and P-C-444 by the NARFS, a comparison of the costs for these cleaners indicated a significant cost savings of approximately $66,270 would be achieved by using MIL-C-43616

wholly in place of the first 2 cleaners and partially for P-C-444 and MIL-C-22542A. Table IV lists these data.

In addition to the savings, the substitution of MIL-C-43616 for P-C-444 Type II would eliminate the use of cresylic acids which are hazardous pollutors and the problem of their disposal.

It is to be noted that the savings quoted in this report hold true for the time period, April 1977, when these prices prevailed. Prices fluctuate rather frequently. For some cleaners there may be a decrease and for others an increase at one time period. At a subsequent period an appreciable change in trend may be experienced.

If the recommendation for cleaner substitution is followed, large volumes of cleaner MIL-C-43616, including the sum total of the volumes of the substituted cleaners, would be purchased as a single item. By purchasing high volumes the cost of the cleaner would be reduced, thus ensuring a cost saving just on volume alone.

CHROMATE INHIBITORS

It is to be noted that inclusion of chromate corrosion inhibitors to the cleaner formulation is optional. Hexavalent chromium, the type found in potassium chromate, constitutes a hazard to the environment and presents a difficult problem in waste treatment and disposal. The conventional methods of extracting chromium from water solution are, the ion exchange process, where the solution is passed through a bed or beds of ion exchange resins and the precipitation process, in which the hexavalent chromium is converted to the trivalent form and subsequently precipitated out.

In view of the low chromium concentration due to the high dilution resulting from the water flushing in the cleaning operation, neither method is practical nor economical.

## C O N C L U S I O N S

Each of the 5 NARFS surveyed indicated treatment of spent cleaner was being made prior to final disposal thus reducing the pollutive impact on the environment.

No efforts are being made to recover waste cleaner components since the methods of application of these cleaners preclude any economic and anti-pollutive advantages gained through reclamation. The substitution of non or less pollutive cleaners or cleaner components for pollutive and hazardous ones is a viable option to minimize or reduce pollutive and also to effect some economic benefits.

## R E C O M M E N D A T I O N S

Based on the findings of this study, it is recommended that:

1. Cleaner MIL-C-43616 be substituted for cleaners MIL-C-11090, MIL-C-25769, MIL-C-22542 and in some applications, other than some NARF's special preference P-C-444.

2. Engine cooling system cleaner MIL-C-10597 be substituted for O-C-00432.

3. Chromates be replaced by other less polluting corrosion inhibitors if inhibitors are required in the cleaner formulation.

4. In consideration of the cleaning procedures practiced at the NARFS which generally result in extremely high dilution of the waste cleaners, no reclamation is recommended.

5. All waste cleaners should be treated before final disposal to reduce adverse effects on the environment.

6. Due to the incompleteness of some usage data obtained, an all inclusive survey of cleaners used at the NARFS should be conducted to determine what other substitution or replacements of cleaners can be made.

7. Records on usage and methods of disposal of waste cleaners should be kept by the individual NARFS. They would serve as an indication of the nature and extent of the impact these waste cleaners may have on the environment. They would also aid in determining the possible cancellation of some cleaners in favor of others having less pollutive formulations.

TABLE I. CLEANERS USED BY THE MILITARY

| Government Specification | Designation | Components | % By Wt. |
|---|---|---|---|
| O-C-00430 | Cleaning compound paint brush | Information not available | |
| O-C-00432 | Cleaning compound engine cooling system | Cleaner part | |
| | | Oxalic acid | 98 min. |
| | | Wetting agent | |
| | | Conditioner part | |
| | | Sodium carbonate | 98 min. |
| | | Wetting Agent | |
| P-C-435A | General purpose (powder, heavy duty) | Alkyl benzene sulfonate (40% active) | 10 |
| | | Sodium metasilicate $Na_2SiO_3$-$5H_2O$ | 90 |
| P-C-437A (MS 36423(MU)) | Cleaning compound high press (steam) cleaner | Sodium metasilicate $Na_2SiO_3$-$5H_2O$ | 35 |
| | | Primary sodium phosphate $NaH_2PO_4$-$H_2O$ | 10.5 |
| | | Sodium tripolyphosphate $Na_5P_3O_{10}$ | 52.5 |
| | | Non-ionic surface active agent mild 16791 Type I | 2.0 |
| P-C-444A (MS 36424 (MU)) | Cleaning compound, solvent, grease emulsifying | Kerosene C | 52 |
| | | Dispersant N-10 (non-ionic) condensation product of $CH_2$-$O$-$CH_2$ and alkyl phenol | |
| | | potassium resin soap potassium tall oil fatty acid soap free acid calculated as oleic acid | 1.5 |
| | | hexylene glycol | |
| Type 2 | | Pet solvent | 62% |
| | | cresylic acid | 20% |
| | | caustic potash | < 5% |
| P-C-446A | Cleaning Compound solvent detergent (for cleaning coils and filters) | $Na_2SiO_3$ $5H_2O$ | 5 |
| | | Non-ionic detergent | 10 |
| | | De-ionized $H_2O$ | 85 |

TABLE I. CLEANERS USED BY THE MILITARY
(continued)

| Government Specification | Designation | Components | % By Wt. |
|---|---|---|---|
| P-C-535 | Cleaning compound, platers electrocleaning for steel | Silicate as $SiO_2$ | 10-35 |
| | | Phosphate as $P_2O_5$ (complex phosphates) anhydrous | 5 min. |
| | | organic detergent (100% active basis) as alkyl aryl sulfonate or alkyl sulfate | 0.4 min. |
| | | Caustic soda | Remainder |
| O-C-1824 (MIL-C-20207C) (MS 36435 (MU)) | Cleaning compound, solvent, heavy duty, liquid | Must not have chlorinated solvent or other toxic solvents | |
| MIL-C-5410B | Cleaning compound, aluminum surface non-flame-sustaining | Ortho phosphoric acid | 23.9 |
| | | Citric acid | 11.9 |
| | | Non-ionic surface active agent MIL-D-16791 Type I | 10.2 |
| | | MEK | 15.3 |
| | | $H_2O$ | 38.7 |
| MIL-C-6864C (MS 36426(MU)) | Cleaning compound, solvent, oil-cooler | 95% ethanol | 10 |
| | | Cresol Usp | 10 |
| | | Methylene Chloride | 70 |
| | | Pot. oleate | 8 |
| | | Polyethylene glycol monalkylaryl ether MIL-D-16791 | 2 |
| MIL-C-25769H | Cleaning compound for aircraft surfaces | Trisodium phosphate Dodecahydrate | 10 |
| | | Triton-X-100 | 2.0 |
| | | Ethylene glycol monoethylether | 6.0 |
| | | $H_2O$ | 82.0 |
| MIL-C-27251A | Cleaning compound aircraft surface low temperature | Petroleum solvent | 67.95 $\pm$.5 |
| | | Diethyl amine | .73 |
| | | Triethanolamine | 1.48 |
| | | Oleic acid | 5.63 |
| | | Sodium heptadecyl-sulfate | 1.56 |
| | | Ethylene glycol | .90 |
| | | Fatty alkylol amide condensate | 18.26 |
| | | t-alkyl primary amine | 3.48 |

TABLE I. CLEANERS USED BY THE MILITARY
(continued)

| Government Specification | Designation | Components | % By Wt. |
|---|---|---|---|
| MIL-C-38736 | Cleaning compound solvent for use in integral fuel tanks | Aromatic naphtha | 50% by vol. |
| | | Ethyl acetate | 20 |
| | | MEK | 20 |
| | | Isopropanol | 10 |
| MIL-C-43616B | Cleaning compound aircraft surfaces | Tetrapyropotassium phosphate | 2.5 |
| | | $Na_2SiO_3$ $5H_2O$ | 0.7 |
| | | Potassium chromate | 0.1 |
| | | Ethylene glycol mono-butyl ether | 5.0 |
| | | KOH (45% by wt.) | 4.2 |
| | | Oleic acid | 8.3 |
| | | Solvesso 150 | 41.7 |
| | | Cyclohexanol | 2.8 |
| | | Monoethanolamine | 6.7 |
| | | Dodecyl benzene sulfonic acid (85%) | 7.2 |
| MIL-C-51340 | Cleaning compound electrical | Silicone fluid | By vol. |
| | | MIL-S-81087 Type II | 50±.5 |
| | | Trichloroethylene | 50±.5 |
| MIL-C-81302B | Cleaning compound solvent Trichlorotrifluoro-ethane 1,1,2-Trichloro 1,2,2-Trifluoroethane | | |
| MIL-C-10597D | Cleaning compound with conditioner and inhibitor for engine cooling systems | Cleaner part | |
| | | Aluminum chloride | 14.6-15.2 |
| | | Oxalic acid | 84.3-85.5 |
| | | Cornstarch | 0.15-0.3 |
| | | Conditioner part | |
| | | Sodium silicate | 51.9-63.5 |
| | | Trisodium phosphate | 22.1-23.8 |
| | | Borax | 18.3-19.8 |
| | | Sodium carbonate | 7.9-9.5 |
| MIL-C-11090 (MS 36436(MU)) | Cleaning compound solvent, self-emulsifying | 10% high flash coal tar naphtha 30% kerosene | 100 pts. by vol. |
| | | Detergent concentrate Cyclohexanol | |

TABLE I. CLEANERS USED BY THE MILITARY
(continued)

| Government Specification | Designation | Components | % By Wt. |
|---|---|---|---|
| | | Ethylene glycol monobutyl ether<br>Diacetone-diethylene triamine condensate<br>Ethanolamine oleate in high flash naphtha<br>Diglycol oleate aromatic amine sulfonate<br>Sorbitan oleate | 12.25 by vol. |
| MIL-C-22542A | Cleaning compound, high pressure cleaner, liquid | Caustic potash<br>$K_2CrO_4$ | 2<br>$<.5$ |
| OOPH31D | | (1) Isopar boil range 405-485°C Humble oil<br>(2) Unitol fatty acid | |
| MIL-C-81964 | Cleaning compound avionic components | Trichlorotrifluoroethane<br>Silicone fluid VV-D-1078<br>Propellant Type 12<br>BB-F-1421 | 74.7<br>.3<br>25 |
| MIL-C-372B | Cleaning compound, solvent (for bore of small arms and automatic aircraft weapons) | Kerosene, butyl cello-solve, water | |
| P-C-436 (MS 36422(MU)) | Cleaning compound, alkali, ferrous and non-ferrous surface | Sodium metasilicate anhyd.<br>Primary sodium phosphate anhyd.<br>Trisodium phosphate anhyd.<br>Non-ionic surfactant<br>Avionic surfactant sodium alkyl benzene sulfonate<br>$C_{12}$-$C_{18}$ alkyl | 31.3<br>12.3<br>24.5<br>1.9<br>23.7 |
| TT-T-291E<br>Type I<br>Type II | Thinner paint volatile spirits, petroleum spirits<br>Bearings cleaner | Type II - constituents allowable compounds with olefinic unsat. - trace | |

TABLE I. CLEANERS USED BY THE MILITARY
(continued)

| Government Specification | Designation | Components | % By Wt. |
|---|---|---|---|
| | | Aromatic compounds with eight or more C atoms except ethylbenzene | 8% |
| | | Ethylbenzene | 20% |
| VV-L-800A | Lubricating oil general purpose preservative (water displacing low temp) flash pt. 275°F min. | | |
| MIL-S-18718 | Safety solvent general use cleaning and grease removing of assembled and unassembled engine components | Dichloromethane | 25±1 |
| | | Perchloroethylene | 5±.5 |
| | | Min. spirits | to make 100% |
| P-C-111 | Carbon removing compound | Ethylene glycol monobutyl ether (3 gals.) Diethyleneglycol diethyl ether (1 gal.) Monoethanolamine (3 pts. to every 45 gals. $H_2O$) | |
| MIL-C-14460B | Corrosion removing NaOH base for electrolytic or immersion application | Type I | |
| | | NaOH | 54 max. |
| | | Sodium gluconate | 25 min. |
| | | Trisod. salt of N-hydroxy ethylene diamine-triacetic acid (3 NaEDTH-OH) | 13 min. |
| | | Others including foamers | 7 max. |
| | | Type II | |
| | | NaOH | 35 min. |
| | | NaCN | 25-35 |
| | | Chelate or sequestrant compound | |
| | | EDTA tetrasodium salt dehydrate) | 25-35 |
| | | Others including foamers | 4 max. |
| MIL-C-19853 | Carbon remover | Cresol | 33.62 |
| | | Phenol | 1.0 |
| | | Methylene chloride | 54.9 |
| | | Oleic acid | 6.8 |
| | | KOH | 3.5 |
| | | EDTA | .16 |

TABLE I. CLEANERS USED BY THE MILITARY
(continued)

| Government Specification | Designation | Components | % By Wt. |
|---|---|---|---|
| MIL-R-7751 | Silicate type paint and varnish remover | | |
| O-S-598 Type II | Sodium hydroxide | Sodium hydroxide | |
| MIL-P-11970 | Potassium Permanganate | Potassium Permanganate | |
| O-S-571 Type II | Sodium carbonate | Sodium carbonate | |
| Turco SMUTGO NC | Aluminum cleaner | HF<br>$HNO_3$ | |
| Turco 3823 | Aluminum cleaner hot tank carbon remover | O-Dichlorobenzene | |
| Turco 4008 (MIL-D-26549) | Alkaline descaling compound for hot section of jet engine parts | | |
| Turco 4213 | Aluminum cleaner | | |
| Turco 5873 | Radome stripper non-phenolic | Methylene chloride thickener<br>Chromate corrosion inhibitor | |
| MIL-D-23962 | | Chevron absorption oil No. 2 | |
| Turco 4215 | Hot tank aluminum cleaner Non-silicated | Sodium nitrate, detergents, emulsifiers | |

TABLE II. CLEANING COMPOUNDS

| Government Specification | Cleaning Compound (Description) | Consumption per Annun (Gallons) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Alameda | Cherry Point | Jacksonville | Norfolk | North Island | Pensacola | Total Used by NARFS |
| MIL-C-372B | Solvent for bore of small arms automatic aircraft | | | | 500 | | | 500 |
| MIL-C-5410B | Aluminum surface cleaner non-flame sustaining | | 300 | | 400 | 660 | 580 | 1,940 |
| MIL-C-6864C | Solvent oil cooler | | | | | 660 | 80 | 740 |
| MIL-R-7751 | Remover - paint and varnish | 54[2] | | 440 | | | | 494 |
| MIL-D-9063 | Desealant integral fuel and oil tanks | 3,545[2] | | | 6,600 | | | 10,145 |
| MIL-P-11970 | Potassium permanganate | 3,040 lbs[1] | | | | | | 3,040 lbs[1] |
| MIL-C-14460 | Corrosion removing NaOH base - electrolyte immersion | 2,500[2] | | 2,500[2] | 5,280 | | | 10,280 |
| MIL-D-19853A | Carbon removing | 9,185 | | | 8,360 | 660 | | 18,105 |
| MIL-D-22542A | High press cleaning liquid | 1,364[2] | 660 | 8,800 | | 900 | 1,100 | 12,824 |
| MIL-P-23962 | Chevron absorption oil No. 2 | 2,257 | | | | | | 2,257 |
| MIL-C-25769 | Aircraft surface | | 2,660 | 870[2] | 3,300 | | 100 | 6,930 |
| MIL-D-26549 (Turco 4008) | Alkaline descaling of hot engine parts | 2,805 | | | | | | 2,805 |
| MIL-C-43616 | Aircraft surface | | | | 40 | 36,000 | 8,000 | 44,040 |
| MIL-C-81294 | Epoxy paint remover | 53,481 | | | 17,600 | | | 71,081 |

TABLE II. CLEANING COMPOUNDS
(continued)

| Government Specification | Cleaning Compound (Description) | Consumption per Annum (Gallons) Alameda | Cherry Point | Jacksonville | Norfolk | North Island | Pensacola | Total Used by NARFS |
|---|---|---|---|---|---|---|---|---|
| MIL-R-81835 | Remover organic coating hot tank type | | | | 4,440 | | | 4,440 |
| OS-571 Type II | Sod, carbonate | 1,430 lbs[1] | | | | | | 1,430 lbs[1] |
| OS-598 Type II | Sod, hydroxide | 5,200 lbs[1] | | | | | | 5,200 lbs[1] |
| PC-111 | Carbon removing | 14,520 | | | | | 220 | 14,740 |
| PC-444A | Solvent grease emulsifying | | 220 | 3,300 | 5,060 | 32,000 | 5,060 | 45,640 |
| PC-535 | Platers electrocleaning for steel | | 220 | 112 lbs[1] | | | 1,800 | 2,020 plus 112 lbs |
| Turco 3823 | Aluminum cleaner hot tank carbon remover | 5,170 | | | | | | 5,170 |
| Turco 4213 | Aluminum cleaner | | | | | 800 | | |
| Turco 4215 | Hot tank aluminum cleaner non-silicated | 2,250 lbs[1] | | | | 1,200 lbs[1] | | 3,450 lbs[1] |
| Turco 5873 | Radome stripper | 2,255 | | | | | | 2,255 |
| Turco Smutgo | Aluminum cleaner | | | | | 660 lbs[1] | | 660 lbs[1] |
| Calgon-SW3 | | | | | | | 3,000 | 3,000 |
| Neoprene Stripper<br>GACO SR-14<br>S-14<br>B&B 50-50 | | | | | 600 | | | 600 |
| | | | | | | | TOTAL<br>plus | 260,000 Gals.<br>13,892 lbs |

NOTE: (1) Data submitted in pounds
(2) Data submitted in pounds and converted to gallons

TABLE III. COMPONENTS OF CLEANERS USED BY THE NARFS

| Component | Toxic Hazard Rating: Chronic Systemic Ingestion | Chronic Systemic Inhalation | Chronic Systemic Skin Absorption | Acute Systemic Ingestion | Acute Systemic Inhalation | Acute Systemic Skin Absorption | Comments |
|---|---|---|---|---|---|---|---|
| Alkyl sulfate | | | | | | | Acute inflammatory and corrosive to tissue. |
| Alkyl benzene sulfonate | | | | | | | No data |
| Aluminum chloride | U | U | U | U | U | U | |
| Amine sulfonate | | | | | | | No data |
| Butyl cellosolve | | | | | | | More toxic than glycols |
| 100 SUS coastal oil | | | | | | | May be carcinogenic |
| Cornstarch | | | | | | | Innocuous |
| Citric acid | | | | | | | Innocuous |
| Cresol | 2 | 2 | 2 | 2 | 2 | 2 | |
| Cresylic acids | 2 | 2 | 2 | 2 | 2 | 2 | |
| Cyclohexanol | | | | 2 | 2 | 1 | A suspected carcinogenic |
| Cyclohexanone | 1 | | | 1 | 1 | | |
| Diacetone alcohol | U | U | U | | 2 | | |
| O-dichlorobenzene | | 2 | | | 2 | | |
| Diethylenetriamine | U | U | U | 2 | 2 | 2 | |

TABLE III. COMPONENTS OF CLEANERS USED BY THE NARFS
(Continued)

| Component | Toxic Hazard Rating: Chronic Systemic — Ingestion | Chronic Systemic — Inhalation | Chronic Systemic — Skin Absorption | Acute Systemic — Ingestion | Acute Systemic — Inhalation | Acute Systemic — Skin Absorption | Comments |
|---|---|---|---|---|---|---|---|
| Diethylamine | | | | | | | Chronic and acute systemic toxicity unknown |
| Diethylene glycol diethyl ether | | | | | | | Toxicity unknown |
| Diglycol oleate | | | | | | | No data |
| Dipropylene glycol methyl ether | | | | | | | Low ingestion toxicity |
| Dispersant N-10 | | | | | | | No data |
| Dedecyl benzene sulfonic acid | | | | | | | No data |
| Ethanolamine oleate | | | | | | | No data |
| Ethanolamine | U | U | U | 2 | 2 | | |
| Ethanol | 1 | 1 | 1 | | | | |
| Ethyl acetate | 1 | 1 | 1 | | | | |
| Ethylbenzene | U | U | U | 2 | 2 | 2 | |
| Ethyl cellosolve | 1 | 1 | | | | | |
| Ethylene glycol | 2 | | | 3 | | | |
| Ethylene glycol monobutyl ether | | | | | | | See butyl cellosolve |
| Ethylene glycol monoethyl ether | 1 | 1 | | | | | See ethyl cellosolve |

TABLE III. COMPONENTS OF CLEANERS USED BY THE NARFS
(Continued)

| Component | Toxic Hazard Rating | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| | Chronic Systemic | | | Acute Systemic | | | |
| | Ingestion | Inhalation | Skin Absorption | Ingestion | Inhalation | Skin Absorption | |
| Ethylene diamine tetracetic acid | 1 | | | | | | |
| Glycerine | | | | 1 | | | |
| Hexylene glycol | U | U | U | 1 | 1 | | |
| Hydrofluoric acid | 3 | 3 | | 3 | 3 | | Very corrosive to skin |
| Isopropanolamine | | | | | | | Toxicity unknown |
| Kerosene | 3 | | | | | | |
| Methyl ethyl ketone | U | U | U | | 2 | | |
| Methanol | 2 | 2 | 2 | | | | |
| Methylene chloride (dichloromethane) | 1 | 1 | 1 | | | | |
| Monoalkyl aryl cellosolve | | | | | | | More toxic than glycols |
| Monobutyl cellosolve | 2 | | | | | | |
| Monoethanolamine | | | | | | | See ethanolamine |
| Mineral spirits | U | U | U | 2 | 2 | | |
| Naphtha (aromatic) | 3 | 3 | 3 | | | | |
| Nitric acid | U | U | U | | 3 | | |
| Octyl phenoxy polyethoxy ethanol | | | | | | | No data |

TABLE III. COMPONENTS OF CLEANERS USED BY THE NARFS
(Continued)

| Component | Toxic Hazard Rating | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| | Chronic Systemic | | | Acute Systemic | | | |
| | Ingestion | Inhalation | Skin Absorption | Ingestion | Inhalation | Skin Absorption | |
| Oleic acid | 1 | | | | | | |
| Oxalic acid | 2 | 2 | | | | | |
| Perchloroethylene | 2 | 2 | 2 | | | | |
| Phenol | 2 | 2 | 2 | | | | |
| Phosphoric acid | U | U | U | 2 | 2 | | |
| Paraffin oil (mineral oil) | | | | | | | Recognized carcinogen of skin and scrotum |
| Potassium chromate | | | | | | | Recognized carcinogen |
| Potassium hydroxide | U | U | U | 3 | | | |
| Potassium oleate | | | | | | | No data |
| Potassium resin soap | | | | | | | No data |
| Potassium tall oil fatty acid soap | | | | | | | No data |
| Polyethylene glycol monoalkyl aryl ether | | | | | | | No data |
| Pentasodium triphosphate | | | | 2 | | | |
| Silicone fluid | | | | | | | Low toxicity |

TABLE III. COMPONENTS OF CLEANERS USED BY THE NARFS
(continued)

| Component | Toxic Hazard Rating | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| | Chronic Systemic | | | Acute Systemic | | | |
| | Ingestion | Inhalation | Skin Absorption | Ingestion | Inhalation | Skin Absorption | |
| Sodium carbonate | U | U | U | 2 | 2 | | |
| Sodium chromate | | | | | | | Recognized carcinogen |
| Sodium cyanide | | | | | | | Very poisonous |
| Sodium gluconate | | | | | | | Toxicity unknown |
| Sodium heptadecyl sulfate | | | | | | | No data |
| Sodium hydroxide | U | U | U | U | U | U | Corrosive to all body tissue |
| Sodium phosphate (monobasic) | | | | | | | Mild irritant |
| Sodium petroleum sulfonate | | | | | | | No data |
| Solvesso 150 | | | | | | | May be carcinogenic |
| Sorbitan oleate | | | | | | | Suspected carcinogen |
| Tetrapotassium pyrophosphate | 1 | 1 | | 2 | 2 | | |
| Tetrasodium EDTA | | | | | | | Highly toxic |
| Trichloroethylene | 3 | | | | | | |

TABLE III. COMPONENTS OF CLEANERS USED BY THE NARFS
(continued)

| Component | Toxic Hazard Rating | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| | Chronic Systemic | | | Acute Systemic | | | |
| | Ingestion | Inhalation | Skin Absorption | Ingestion | Inhalation | Skin Absorption | |
| Triethanolamine | 3 | | 1 | | | | |
| Trisodium EDTA | | | | | | | No data |
| Triton X-100 (see octyl phenoxy polyethoxy ethanol) | | | | | | | No data |

NOTE:

TOXIC HAZARD RATING CODE

1. SLIGHT - causes readily reversible changes which disappear after end of exposure
2. MODERATE - May involve both irreversible and reversible changes not severe enough to cause death or permanent injury
3. HIGH - May cause death or permanent injury after very short exposure to small quantities

U UNKNOWN - No information on humans considered valid by authors

TABLE IV. ECONOMICS OF REPLACING MIL-C-22542, MIL-C-25769, AND PC-444 (FOR CERTAIN APPLICATIONS) WITH MIL-C-43616[2]

| Cleaner | Total Vol. Used at NARFS per Annum (Gals.) | Cost to Govt.[3] per 55 Gals. | Cost per Gal. | Cost of[3] MIL-C-43616 per Gal. | Savings per Gal. | Savings per Total Vol. Used per Annum |
|---|---|---|---|---|---|---|
| MIL-C-25769 | 7,020 | $ 72.76 | $1.32 | $.80 | $ .52 | $ 3,650 |
| MIL-C-22542 | 12,820 | $184.04 | $3.35 | $.80 | $2.55 | $16,350[1] |
| PC-444 | 45,640 (22,820) | $150.80 | $2.74 | $.80 | $1.94 | $44,270[1] |
| | | | | | | $66,271 |

NOTE:

1 - Assume replacing ½ total volume of PC-444 and MIL-C-22542 for application that MIL-C-43616 can fulfill.

2 - Total volume of MIL-C-43616 used per annum at the NARFs is 44,040 gallons at $43.87 per 55 gallon lots.

3 - Prices are as of April 1977.

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